WG WatershedGeo®
Unearthing Solutions

ENVIRONMENTAL CLOSURE SOLUTIONS FOR LANDFILLS

MISSOURI
DEPARTMENT OF
NATURAL RESOURCES

February 21, 2018

ABOUT WATERSHED GEO

- Company founded in 2007 by Civil Engineers
- Based in Alpharetta, GA
- Over 100…
  - Years of landfill experience
    - Design, Construction, Maintenance and Management
  - Years of geosynthetic experience
  - Individual sites managed through closure & post-closure
- 20% ownership held by Shaw Industries, A Berkshire Hathaway Company
- Partnered with Agru America for market development and structured geomembrane supply

Shaw®

BERKSHIRE HATHAWAY INC.

MADE WITH agru STRUCTURED MEMBRANES

CLIENTS SERVED

ClosureTurf®

A PREDICTABLE BENCHMARK OF PERFORMANCE

WG WatershedGeo® Unearthing Solutions

PREDICTABLE PERFORMANCE

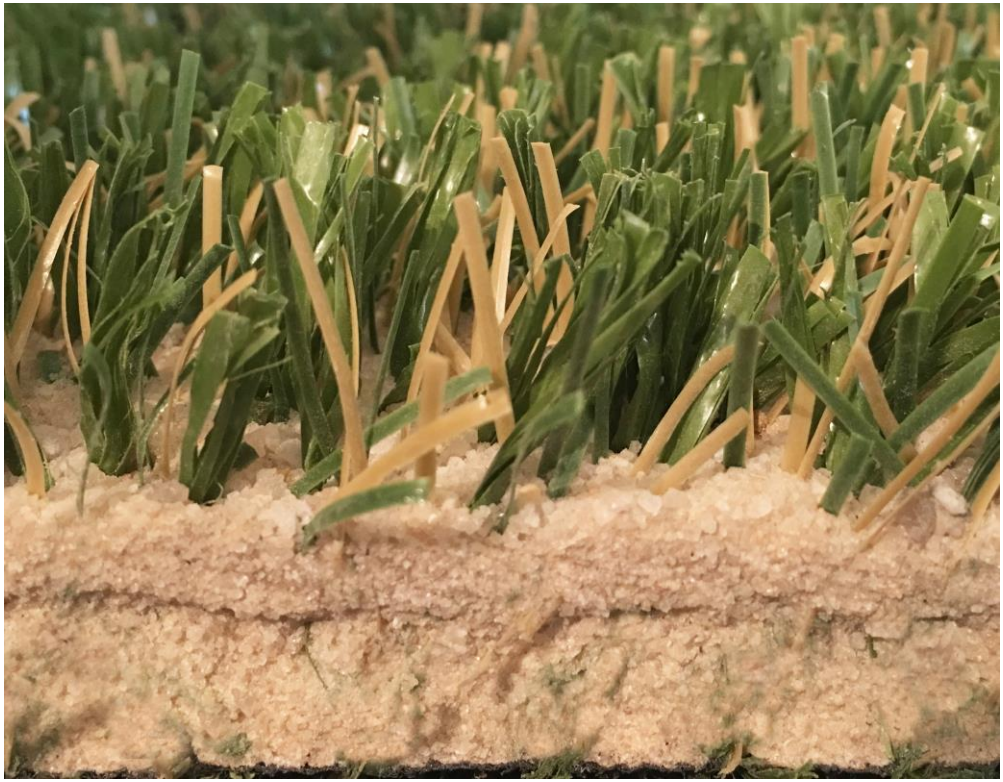
- ClosureTurf® is the **only** solution that provides a predictable benchmark of performance.

- Compare this to a prescriptive cover, which is effectively an engineered structure reliant upon vegetation and weather to perform as designed.

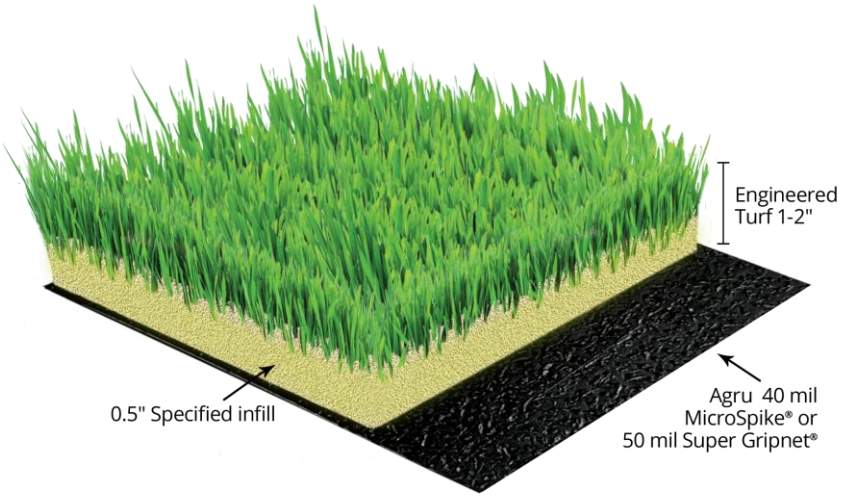
- **Predictable Performance Checklist:**
  - Construction Cost
  - Construction Schedule
  - Technical Performance
  - Maintenance Cost
  - Design Life

CLOSURETURF® TECHNOLOGY

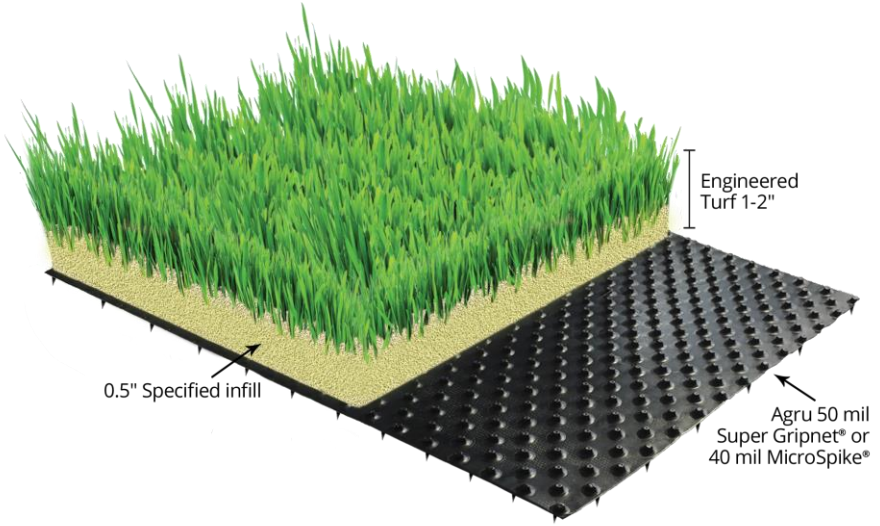
- **Structured Geomembrane:** May include integrated studs on top for drainage/ aggressive spikes on bottom for stability
- **Engineered Synthetic Turf:** Covers and protects the underlying geomembrane
- **Specified Infill:** ASTM C-33 Sand, Polymeric Binder or Cementitious Infill



CLOSURETURF® SYSTEMS



Typical Applications



Steep Slopes or Seismic

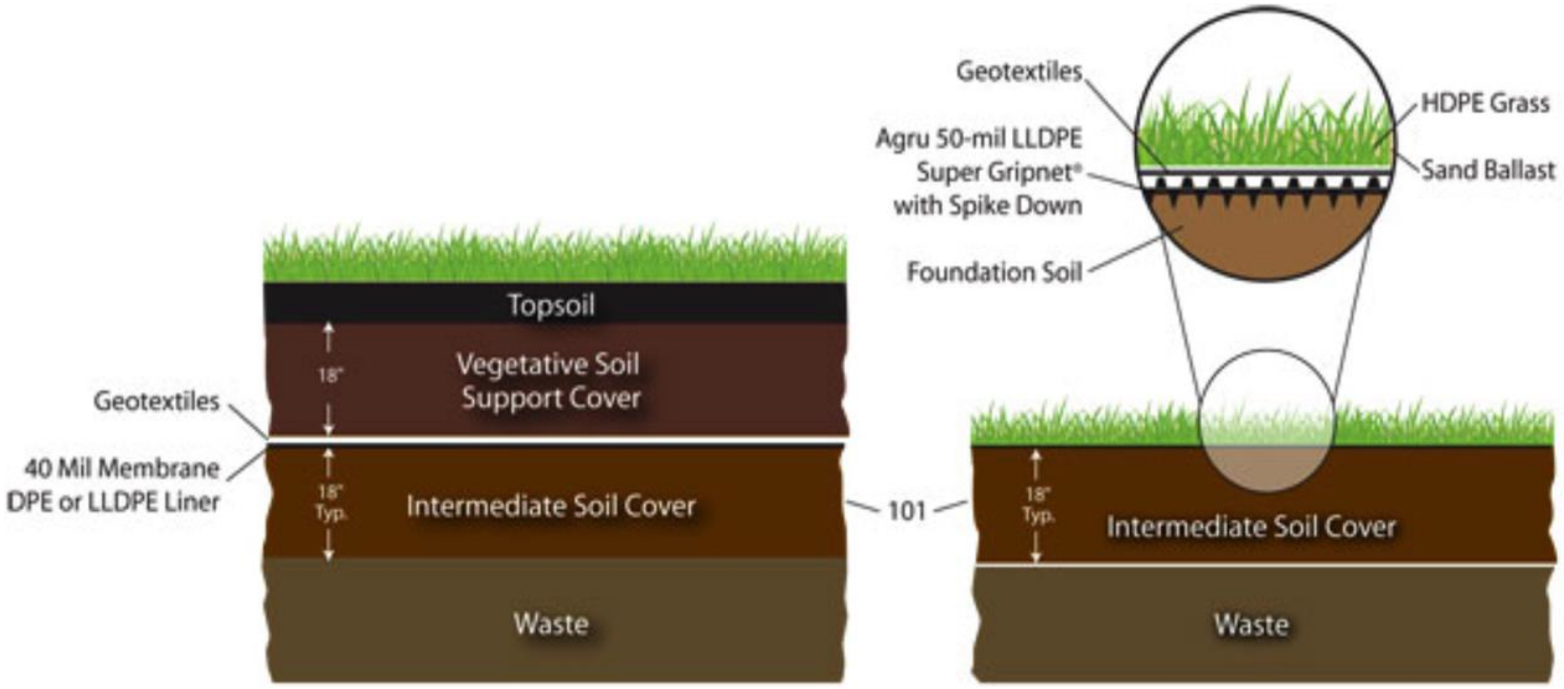
ENGINEERED TURF COLOR OPTIONS

Olive Green

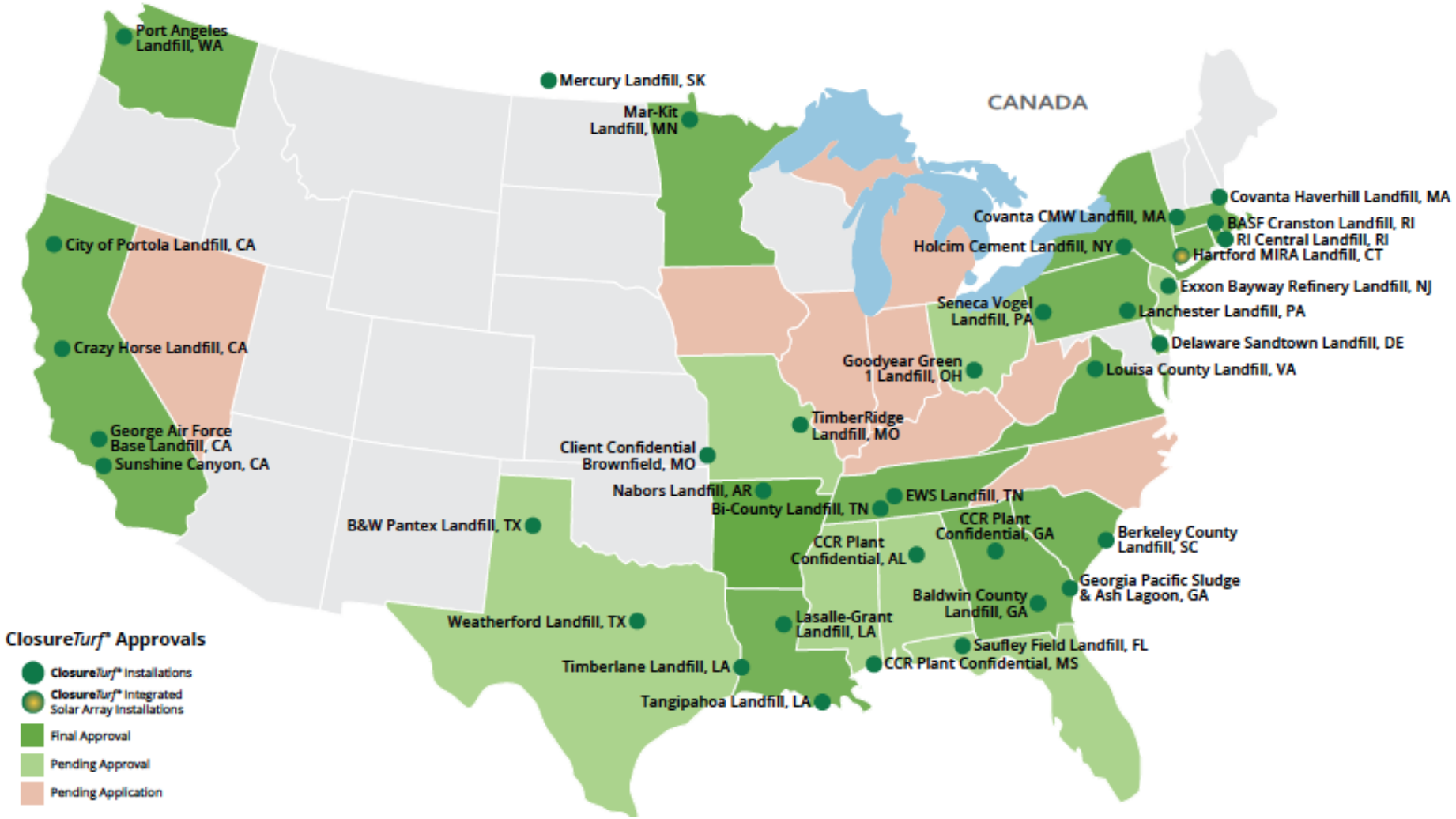
Blend

Tan

COMPARISON


Geotextiles
Agru 50-mil LLDPE
Super Gripnet®
with Spike Down
Foundation Soil
HDPE Grass
Sand Ballast
Topsoil
18"
Vegetative Soil
Support Cover
Geotextiles
40 Mil Membrane
DPE or LLDPE Liner
18"
Typ.
Intermediate Soil Cover
Waste
101
18"
Typ.
Intermediate Soil Cover
Waste

OVER 1,000 ACRES OF CLOSURETURF® INSTALLED



PREDICTABLE CONSTRUCTION

- Installs at least **50% faster** than traditional soil caps
- Eliminates on average **550 truck trips**, per acre, from local roadways
- **Incremental** closures (“close as you go”)
- Eliminates 2’ of soil layer; no soil borrow

PROJECT PROFILE

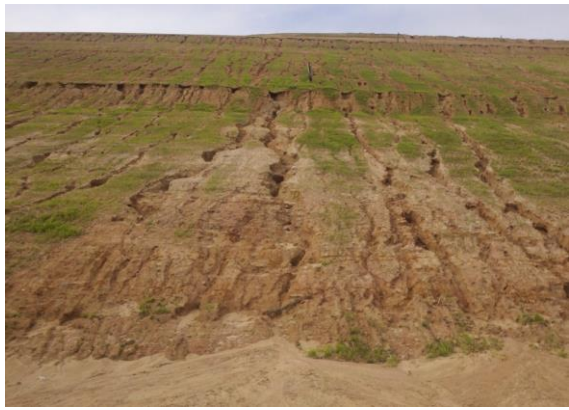
Saufley Field Landfill

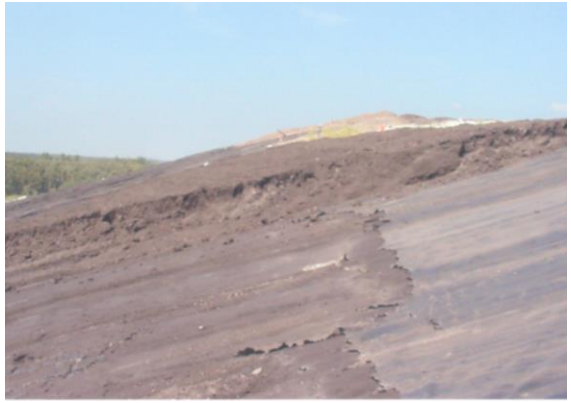
Pensacola, FL

25 acres in 6 weeks

PREDICTABLE PERFORMANCE

EROSION CONTROL



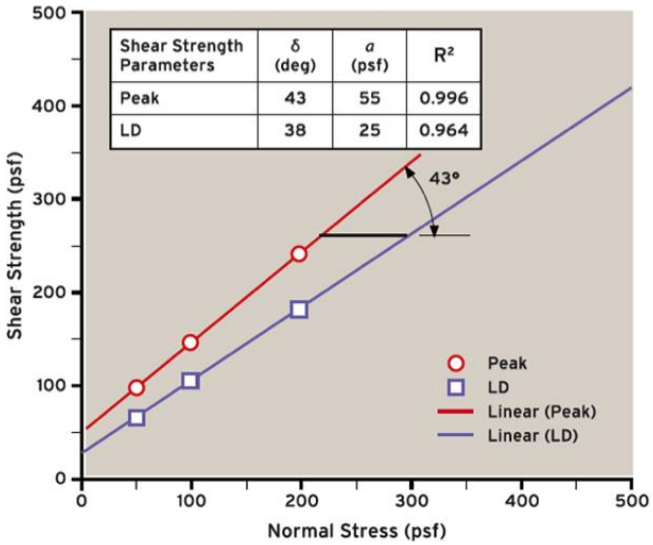


INTERFACE FRICTION & SLOPE STABILITY

Sliding of the soil cover is a concern, especially after major storm events.

By removing the soil in combination with Agru's high interface friction Super Gripnet®, ClosureTurf® provides **greater stability on steeper grades** and **eliminates the need to rebuild slopes.**

Slope angle	Slope	SF
33	1.5H: 1V	1.4
26	2.0 H: 1V	1.9
18	3.0H: 1V	2.8
14	4.0H: 1V	3.7



SLOPE STABILITY
ASTM D-5321

PROJECT PROFILE

Port Angeles Landfill

Port Angeles, WA

Slopes are 2.5:1 with longest slope at 285 ft.

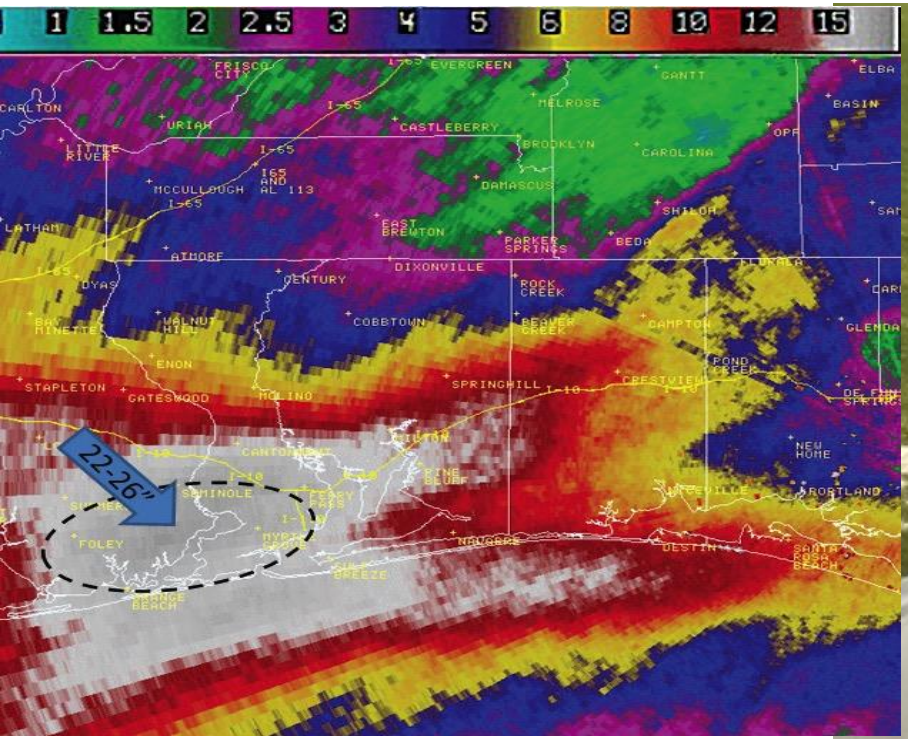
HYDRAULIC PROPERTIES

- TRI Facility in South Carolina (ASTM D-6459 and ASTM D-6460)
- 3:1 Slope, 8’ x 40’
- Tests replicate rain induced forces @ 2”, 4” and 6” per hour
- Zero infill movement at 2” and 4” rain events per hour; 0.03 tons per acre of movement at 6” rain event
- Clearly outperforms prescriptive cover systems which allow for 5 – 10 CY per acre per year

PROJECT PROFILE

Saufley Field Landfill

Pensacola, FL



April 2014 - 26” of rain fell in a 24-hour period

1 hour intensity – 500 year event

Minimal maintenance – 3 days/3-man crew

PROJECT PROFILE

Saufley Field Landfill

Pensacola, FL

As reference, this was Saufley Field before ClosureTurf® after heavy rain.

WIND TUNNEL TESTING

Tested at Georgia Tech Research Institute **up to 120 mph** (factor of safety >2.0)

Based on the overall test results, the ClosureTurf System is projected to **withstand 150+ mph winds** when properly designed.

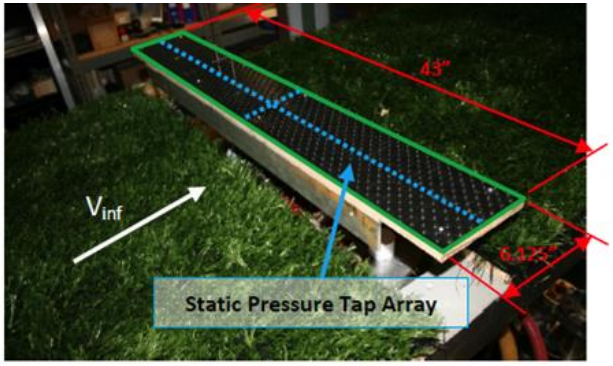


Figure 1a – Model Before Final Turf Layer

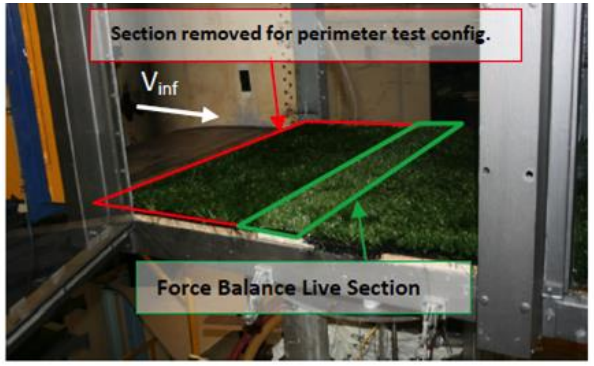


Figure 1b – Turf Installed & Model Lowered

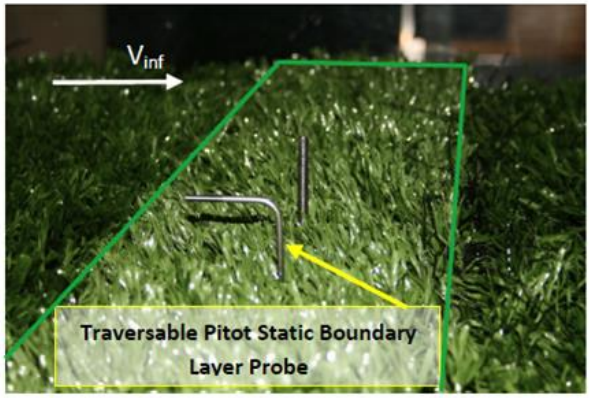


Figure 1c - Pitot Static Boundary Layer Probe

Figure 1d – Full Installation Looking Downstream

PROJECT PROFILE

Berkeley County Landfill

Moncks Corner, SC

Berkeley County Landfill survived Hurricane Matthew (85+mph winds) in 2016 with no damage or maintenance required.

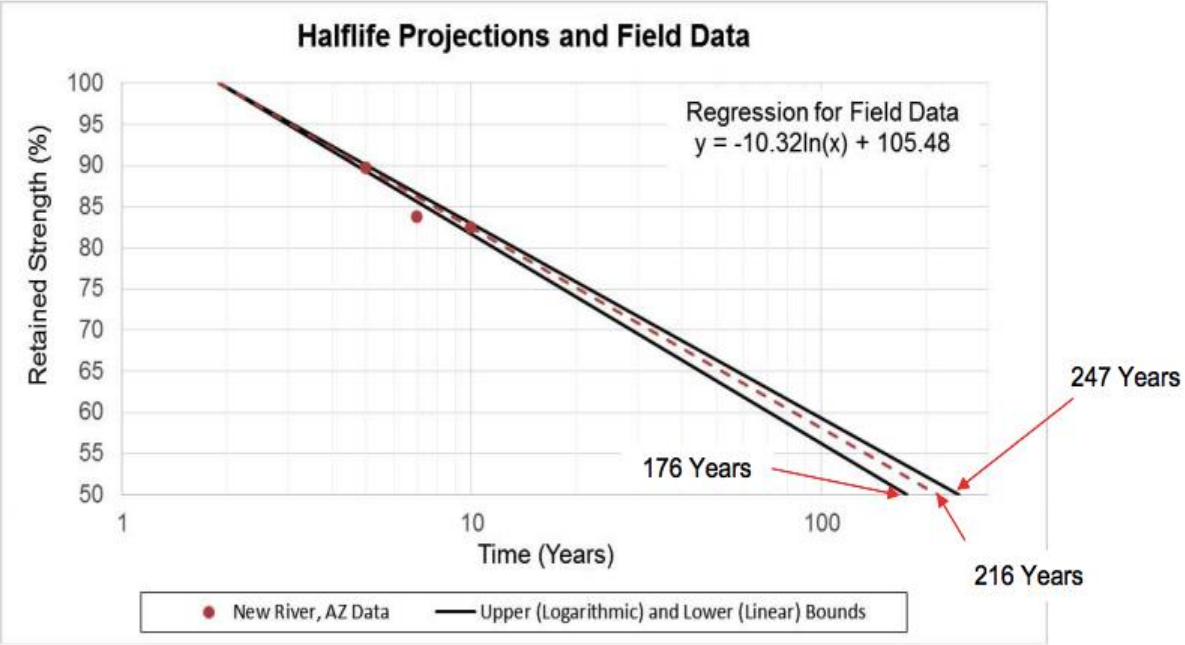
WEATHER AND UV RESISTANCE

- **Real world testing conducted at the Atlas Weathering Facility in New River, AZ**
- **Over ten years of data collected**
- **More than six (6) times the tensile strength required is retained in the system when projected to 100 years**

LONGEVITY ANALYSIS

Designed for and proven to have a design life **over 100 years** of the infilled engineered turf with the underlying geomembrane lasting many more years beyond the long life of the engineered turf component.

*SWANA recently reported **200+ years** of design life.



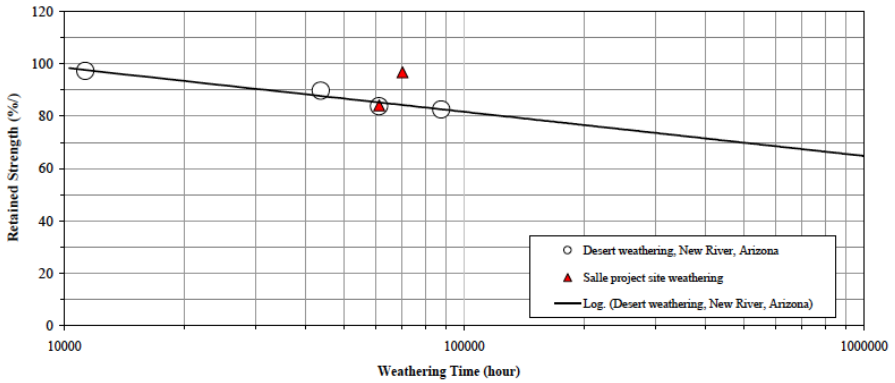
- Geosyntec study
- Need 3.5 lbs of tensile strength in the turf fiber
- Turf Fiber has 35 lbs at time of manufacture
- Projected to retain 65% (23 lbs) at 100 years
- More than six (6) times the tensile strength needed at 100 years

PROJECT PROFILE

LaSalle Grant Landfill

Jena, LA

CLOSURE TURF LLC -LANDFILL COVER SYSTEM
RETAINED TENSILE STRENGTH VS. WEATHERING TIME
Desert Weathering VS. Salle Project Site Weathering



Weathered ClosureTuff™	Weathered Conditions	Test Specimen	Weathering Time (year)	Weathering Time (hours)	Tensile Strength Control (lbs)	Tensile Strength Weathered (lbs)	Tensile Strength Weathered (%)
1	Desert weathering, New River, Arizona	Top Portion	1.3	11280	25.4	24.7	97.2
2	Direct 45 deg South with plywood packing	2" long	5.0	43800	20.2	18.2	89.7
3		green yarn	7.0	61320	20.2	17.0	83.8
4			10.0	87600	20.2	16.7	82.5
5	Salle project site exposure	3" long	7.0	61320	20.2	17.0	84.2
6	facing south on slope	green yarn	8.0	70080	46.2(1)	44.7	96.8

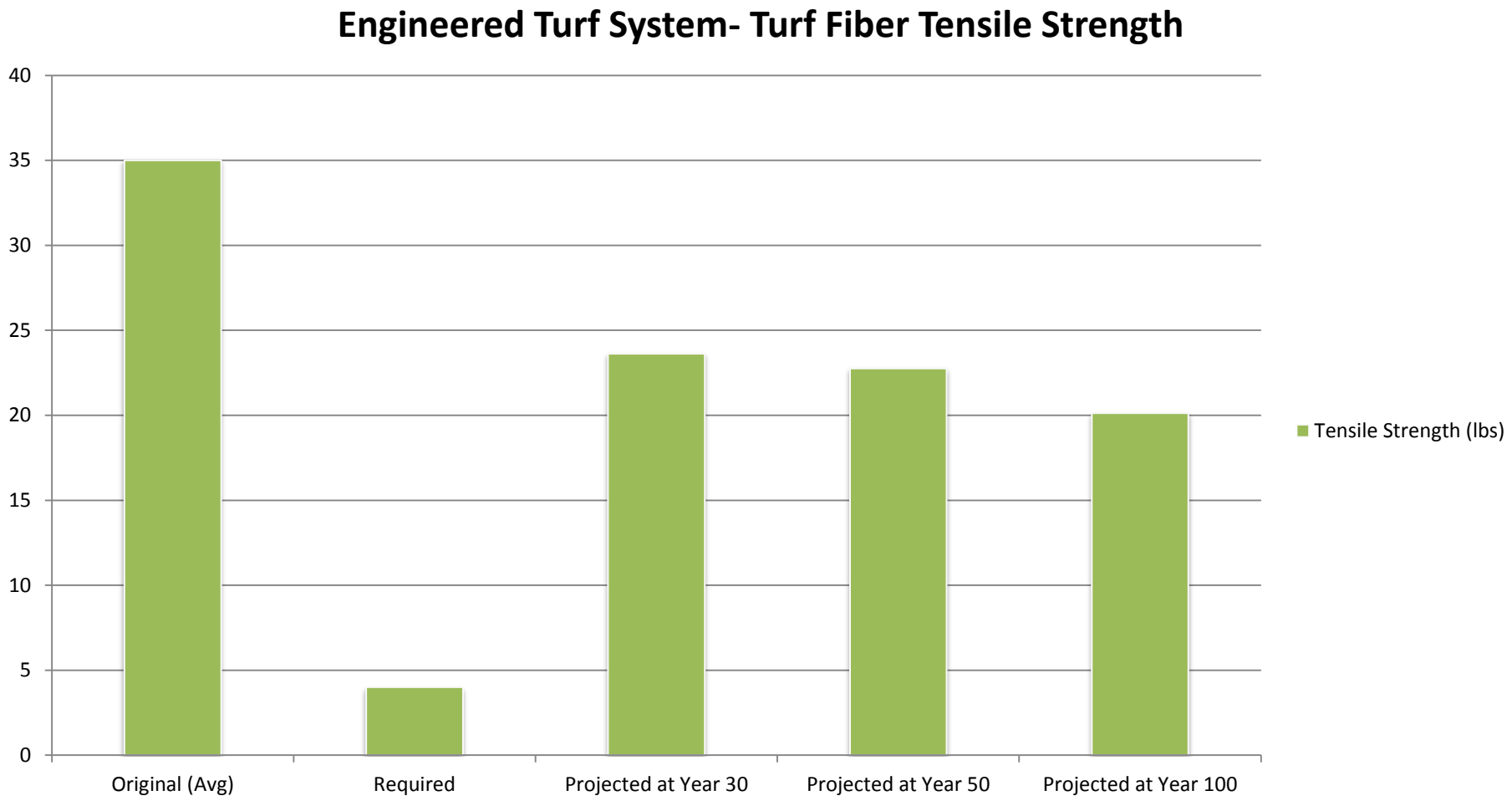
NOTE (1) control strength determined from the trench sample from the same site.

SGI TESTING SERVICES, LLC

DATE REPORTED	10/27/2016
FIGURE NO.	1
PROJECT NO.	SGI16014
DOCUMENT NO.	
FILE NO.	

8 year sample taken from our oldest installations in 2017.

LONGEVITY ANALYSIS



BENCHLESS DESIGN

- ArmorFill™ environmentally-friendly binding agent added to sand
- **Eliminates** critical slope length issue
  - Sand is bound in place
- Diversion berms and downslope channels are **no longer required**
- Storm water is kept in sheet flow & shallow concentrated flow
- Detention settlement is **unnecessary**
- Perimeter ditch can discharge directly offsite

PROJECT PROFILE

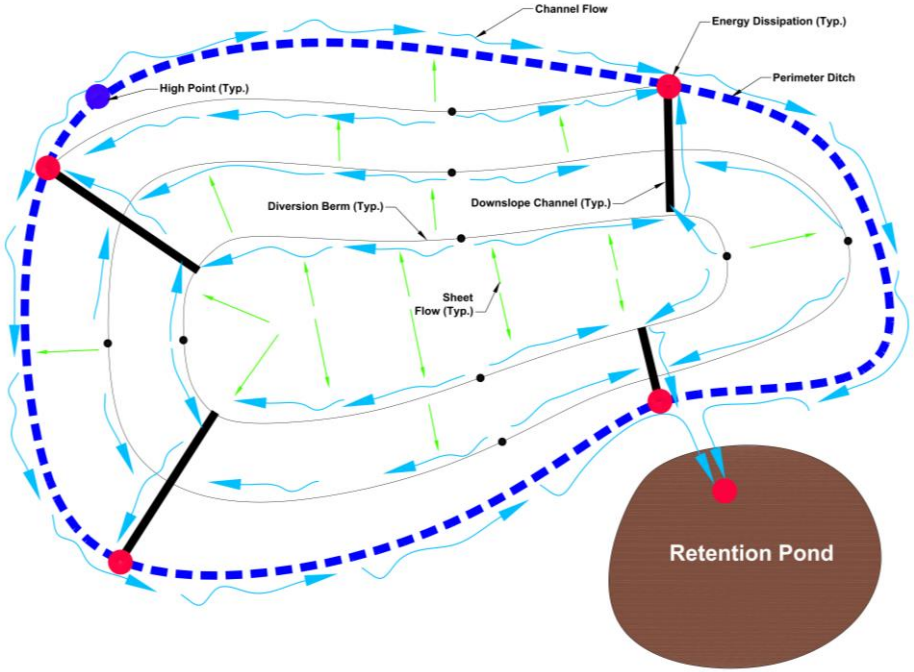
Baldwin County Landfill

Milledgeville, GA

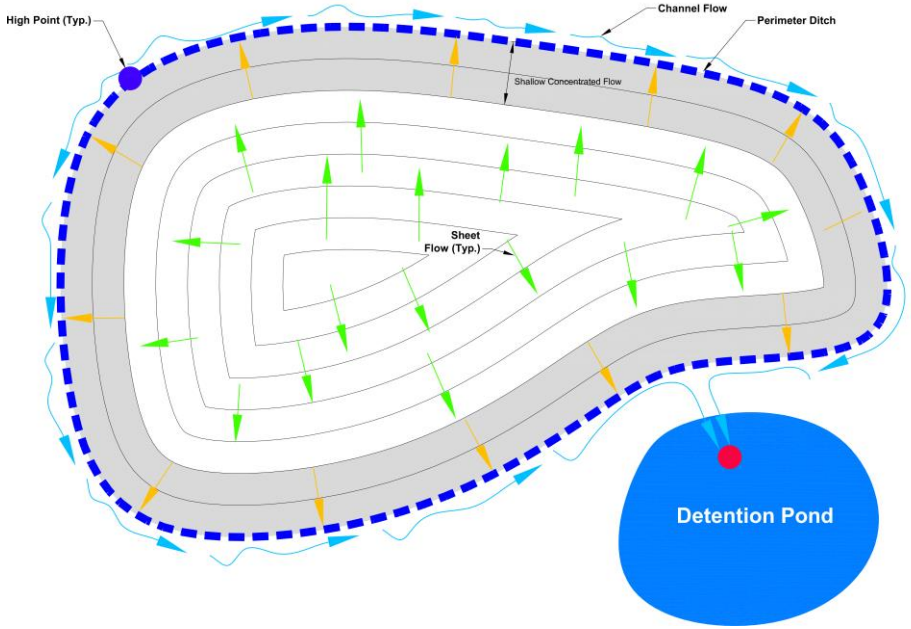
Design saved $1.5 million.

Awarded the 2017 Georgia Chapter American Public Works Association engineering award.

BENCHLESS DESIGN



Typical Hydrology Design



ClosureTurf® with ArmorFill™

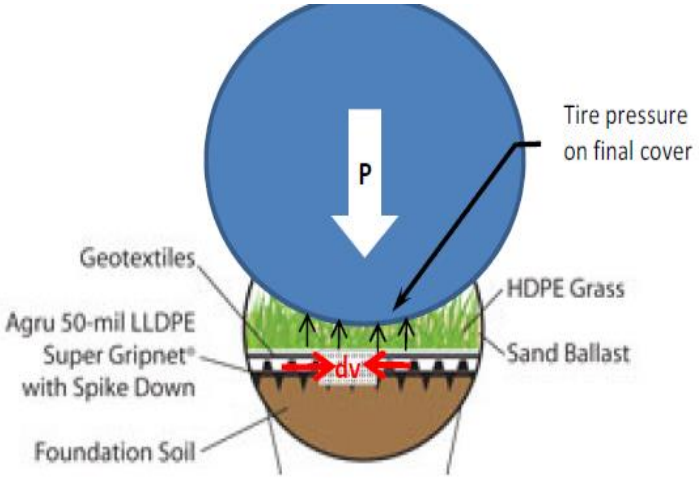
GEOTECHNICAL STABILITY

Can be driven on **without damage** to the system

Factors of Safety for heavy vehicle static weight and braking forces all **above 1.5.**

Slopes- <60 psi

Access roads/top decks- <100psi



PREDICTABLE PERFORMANCE

LONG-TERM ENVIRONMENTAL EFFECTS

WATER QUALITY

The engineered synthetic turf and infill effectively filters surface water, providing **clean runoff** with very **low turbidity**.

No soil, chemicals, fertilizers, etc. to contaminate the water.

Reduces sediment loading to surrounding channels and sedimentation/detention basins both on and offsite.

Improves effluent levels to meet or be well below the regulatory limits.

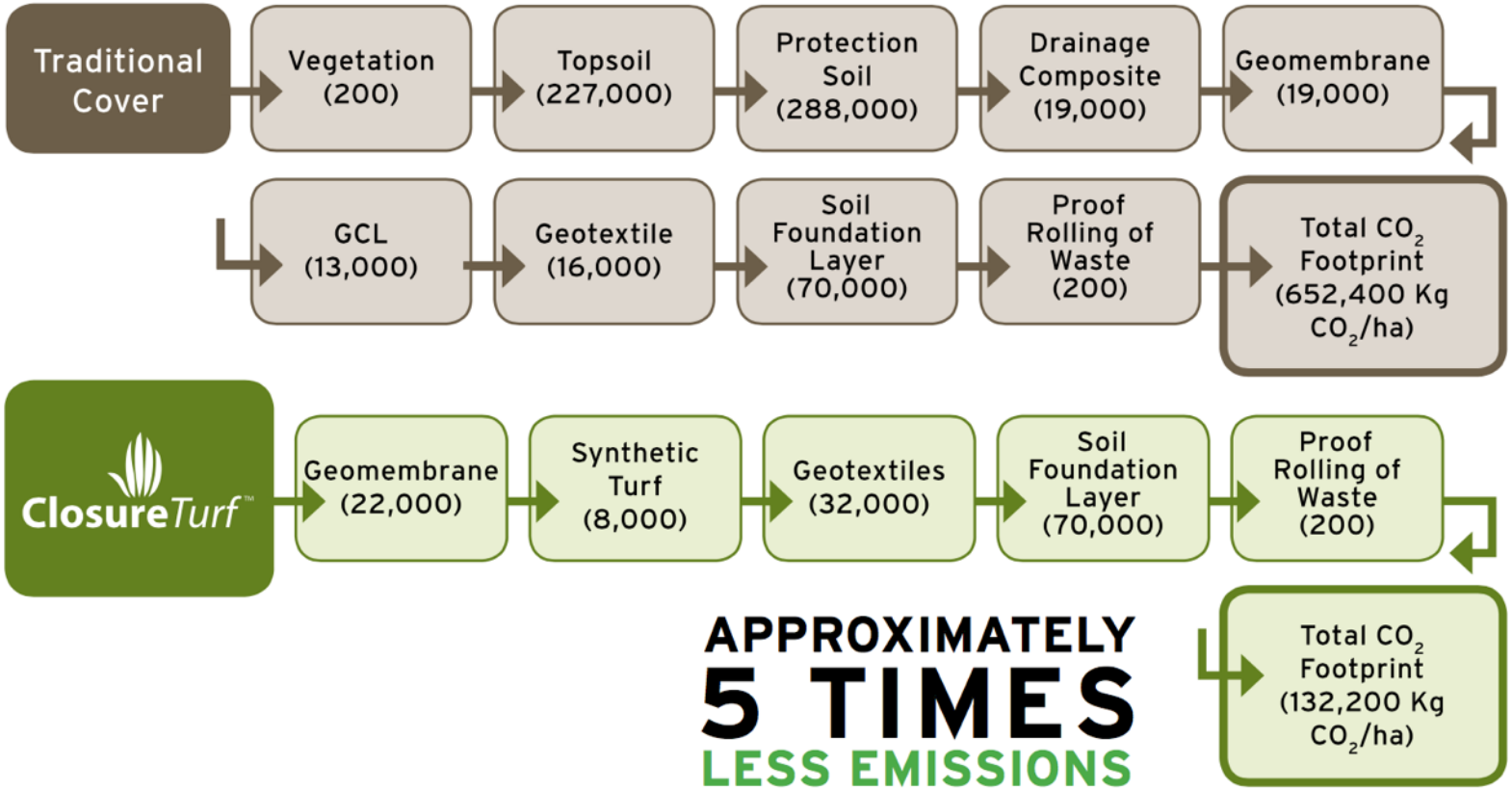
PROJECT PROFILE

Tangipahoa Landfill
Pensacola, FL

Soil cap versus ClosureTurf®

Decreased sediment loading of cover runoff by ~97%

ClosureTurf¨ reduces the carbon footprint of a closure by approximately 80% when compared with traditional soil/vegetative covers.



SAFE HABITAT

ClosureTurf® is **safe** for all animals.

It is **not an effective habitat** for a **burrowing** animal, as it would be unlikely to spend any significant time on top of ClosureTurf due to the lack of effective cover and/or shielding from predators (i.e. birds of prey). If by chance evidence of burrowing was discovered, it is easily repaired due to the lack of soil.

To date, there is **no evidence** of any burrowing animal activity at all on ClosureTurf.

SOLAR INTEGRATION

Traditional racking system:

- Clean foundation free of grass clippings, dust and potential damage from lawn equipment
- Maximize top deck, unusable space

New, patented rackless system:

- Slope integration
- Increased density
- Lightweight
- Highly versatile, aesthetic design
- Protects against mechanical expansion

PROJECT PROFILE

Hartford MIRA Landfill

Hartford, CT

Over 1,500 MW hours of clean renewable energy capable of powering 1,000 residential homes at peak efficiency.

PREDICTABLE MAINTENANCE

POST CLOSURE CARE




POST CLOSURE CARE

ClosureTurf® greatly reduces maintenance and post-closure care **by around 90%** compared to traditional soil and vegetated systems.

There is **no nee**d for irrigation, fertilizing, seeding or mowing.

Sand infill should be inspected every 5 to 10 years but to date **less than 2%** of sand loss has been reported on any ClosureTurf site.

POST CLOSURE CARE

Traditional Cap	Advanced Engineered System
Mowing (4 events per year)	Not Required
Erosion Control (1 event per 25 acres, twice per year)	Not Required
Reseeding (1/3 area, twice per year)	Not Required
Fertilizing (1/3 area once per year)	Not Required
Soil Replacement (typical 1 ton/per acre per year average- per EPA)	Sand Infill Replacement (<2% total area every 5 years)
Pond Cleanout (avg once per every 4 years)	Not Required
Major Storm Repair (4 hours equipment after 1 event/year)	Not Required
Site Inspection (1 inspection per quarter)	Site Inspection (Every 5 to 10 years)
Financial Assurance (-2% per year)	Financial Assurance (-2% per year)

PROJECT PROFILE

Louisa County Landfill

Mineral, VA

ClosureTurf® allowed for an additional two feet of waste (45,000 cy) valued at $1.5M.
Saves $45,000/year on maintenance.

HydroTurf®

AN ADVANCED STORM WATER MANAGEMENT SYSTEM FOR LANDFILLS

HYDROTURF® APPLICATION

- Downchutes
- Perimeter Channels
- Bench Drains
- Outfall Structures
- Slopes
- Basins

HYDROTURF® BENEFITS

- Excellent Hydraulic Performance (able to withstand 40 ft/s velocities)
- Flexible; Performs under Settlement Conditions
- Impermeable
- Lightweight
- Easier to Install in Difficult Access Areas
- Minimal Maintenance
- Easy to Repair
- Aesthetics; Six Color Styles to Blend w/ Natural Environment

PERFORMANCE *VERSUS* TRADITION

See how HydroTurf® compares to other storm water management systems for landfills.

	Installed Cost ($/SF)	Installed Cost ($/LF for 12' Wide Channel)	Hydraulic Performance	Installation Rate	Aesthetics	Performs Under Settlement	Maintenance
HydroTurf®	**$5 - $8 /SF**	**$60 - $96 /LF**	**Excellent**	**Moderate**	**Yes**	**Yes**	**Minimal**
Rock Riprap	$4 - $10 /SF	$48 - $120 /LF	Poor	Moderate	No	No	High
Pipe	-	$30 - $50 /LF	Poor – Good	Moderate	No	No	High
Articulated Concrete Block	$10 - $18 /SF	$120 - $216 /LF	Good	Slow	Depends	No	Moderate - High
Concrete	$8 - $12 /SF	$96 - $120 /LF	Excellent	Slow	No	No	Moderate
Gabions / Reno Mattresses	$8 - $14 /SF	$96 - $120 /LF	Good	Slow	No	No	High
Fabriform	$6 - $9 /SF	$72 - $108 /LF	Poor	Moderate	No	No	Moderate - High

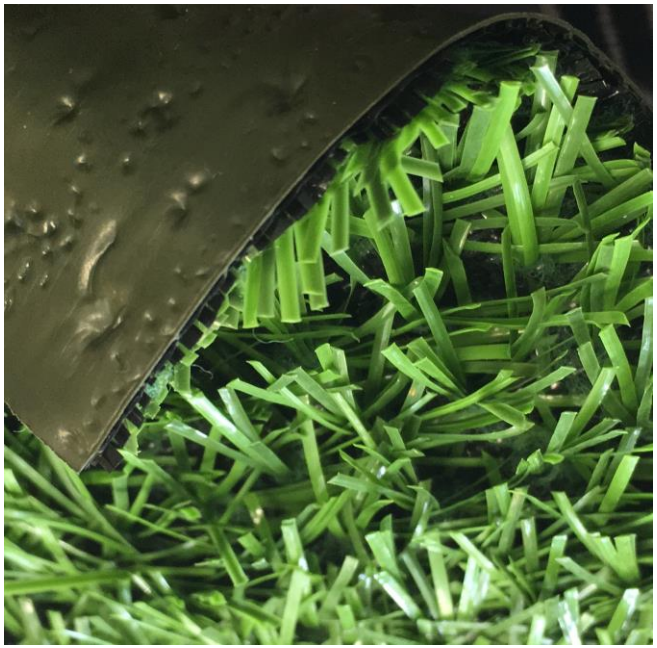
** All costs are estimates and may vary depending upon project size, geographic location and market conditions.*

VERSACAP® INTERMEDIATE COVER

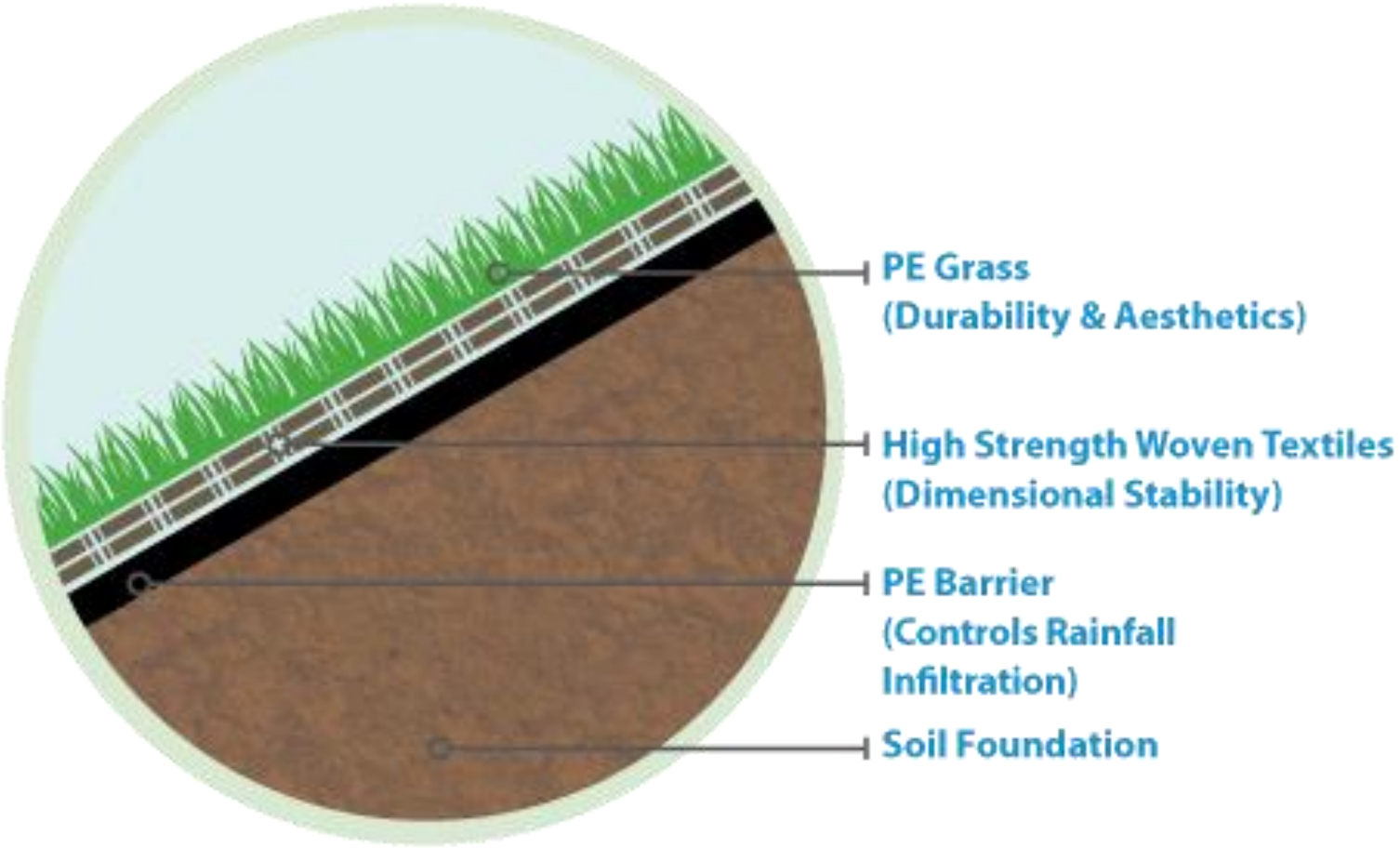
Two-Component Intermediate Cover

1. **Engineered Turf with Polyethylene Backing** - Erosion resistant, low infiltration engineered turf with a high strength polyethylene backing.

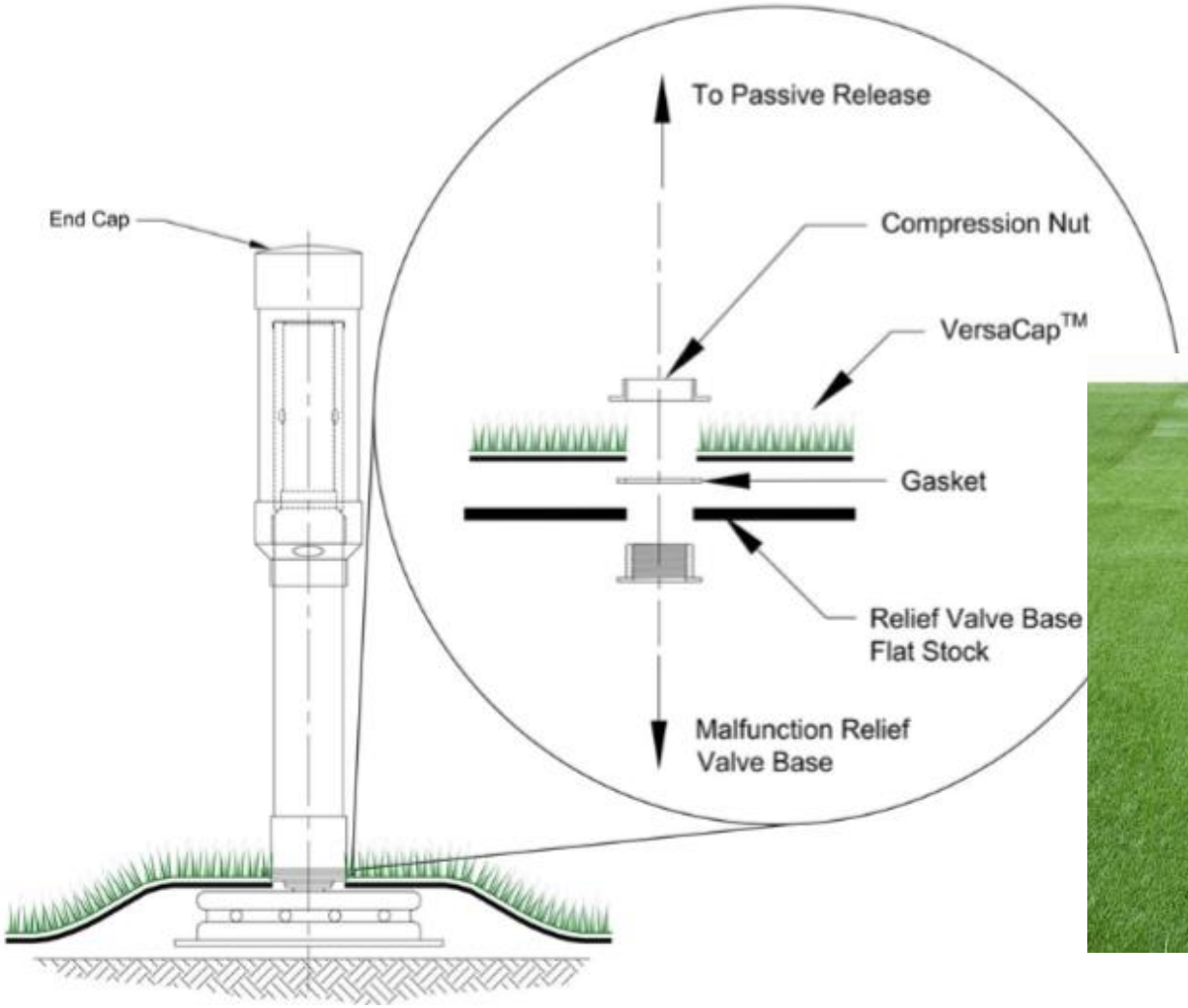
2. **Malfunction Relief Valves** – Gas collection system that will vent gas buildup from underneath the VersaCap liner.



VERSACAP® CROSS SECTION



VERSACAP® MALFUNCTION RELIEF VALVE



SEAMS WELDED, NOT SEWN

TYPICAL APPLICATIONS

- Temporary Landfill Cover
- Landfill Gas Odor Control
- Erosion Control / Turbidity Reduction
- Temporary Stockpile Cover

STAYS IN PLACE

- No Sand In-Fill
- No Horizontal Anchor Trenches
- No Earth Anchors (i.e. Platipus Anchors)
- No Sandbags, Tires or Ropes

WG Watershed Geo®
Unearthing Solutions

THANK YOU!